

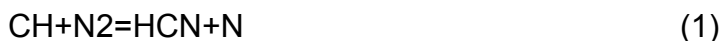
## The Chemistry of Reburning

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This paper discusses the equilibrium and chemistry of reburning and presents examples of successful use of reburning and how the chemistry of reburning limits the NO<sub>x</sub> level that can be achieved. The environmental regulatory agencies are now asking that the emissions of NO<sub>x</sub> be less than 0.15 lb NO<sub>2</sub>/MBTU (108 ppm NO, d, 3 % O<sub>2</sub>). Reburning can help achieve that low level of NO<sub>x</sub>. However, the level NO<sub>x</sub> that can be achieved is limited by the NO<sub>x</sub> equilibrium at the temperature window in which the reduction reactions are active.

This paper presents the chemical limits of reburning based on calculations, and data from a laboratory test, on a 10 MBTU/hr pilot scale test, the results from the retrofit of the Niles OH 125 MWe cyclone unit, and the new installation of the UCLA 125 MBTU/hr boiler. The experimental results conform to the limits defined by the calculations.

Classically reburning required a rich stoichiometry where hydrocarbon fragments could react with molecular nitrogen to form single nitrogen compounds such as the reaction as in equation (1) and (2) originally proposed by Fenimore (1971) to produce prompt NO



and (3) and (4) originally proposed by Sternling and Wendt (1972).



Reburning depends on low NO concentration at equilibrium and fast reaction that can reduce NO. All the single nitrogen compounds, HCN, CN, NH, and NH<sub>2</sub> can react with NO under rich conditions to form N<sub>2</sub>. Reactions (2), (3), and (4) require multiple steps and are likely to be slow.

The amount of NO reduction will depend on the equilibrium concentration of NO. The equilibrium concentrations of NO is low when the stoichiometry is rich and or

the temperature is low. For instance, the equilibrium NO at 1600 K and 1.20 excess air is 785 ppm, but at 0.8 excess air is 0.03 ppm. Equilibrium NO at 1000 K and excess air of 1.2 is 12.5 ppm. However, obtaining equilibrium NO depends on fast active reactions and is seldom obtained in practice.

Reburning is typically accomplished under overall fuel rich conditions. This will require two penetrations, one to inject the secondary fuel and one to complete oxidation of the secondary fuel to avoid corrosion of the superheaters. However, the original MHI patent did not exclude reburning under overall lean conditions. Mitchell (197) showed that NO was reduced on the inside of a diffusion flame. The original MHI patent did not exclude use of reburning. Because of the gradients in oxygen and the nature of the reburning reaction Energy System Associates (ESA) has been able to successfully install and operate a number of lean reburning systems.

The equilibrium and kinetic concepts of this paper have been proved in NH<sub>3</sub> injection in the laboratory, Pilot scale furnaces and operating boilers. A reburning system was designed and tested for the 125 MWe coal –fired Cyclone at Niles, OH with Combustion Engineering and ESA. IN this unit exit NO was almost a 1000 ppm. However, the NO was all made early in the boiler and there was negligible increase in NO after the screen tubes. The reburning system was successful and reduced the NO to less than 500 ppm with low CO at the superheater.